CONSTRUCTION AND USE OF FARM WEIRS

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CONTENTS.

NEED OF FARM WEIRS.

In the arid west vast sums of money have been expended in the construction of ditch and canal systems to carry water to the lands where the rainfall is either insufficient or too uncertain for profitable agriculture, and the farmers have spent a still greater amount for preparing the land for irrigation and for purchasing "water rights," which entitle them to a certain amount of water. The value of the water has increased with the development of the country and now there is a general demand that the water be measured from the ditch to the irrigator as well as from the stream to the main canal. This is an important step toward better business methods in the management of canal systems and farms, and calls for accurate and reliable information concerning devices suited to the measurement of comparatively small streams of flowing water.

DEFINITIONS.

The "weir" is one of the most commonly used devices for this purpose. A bulkhead or wall built across a ditch or stream, with an opening cut in the top of the wall through which the water is allowed to pass, is called a "weir" and the opening is called the "weir notch." The bottom portion of the ditch immediately upstream from the bulkhead is the "weir box" or "weir pond." The height of the water surface in the weir pond above the weir crest is the "head." When the water flows over the crest into the air before it strikes the surface of the water in the ditch downstream from the bulkhead, it is said to have "free fall," and when this overpouring stream of water touches only the sharp upstream edge of the crest, the weir is

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NOTE.—The work on which this bulletin is based was done in the hydraulic laboratory at Fort Collins, Colo., under a cooperative agreement between the Office of Experiment Stations, United States Department of Agriculture, and the Colorado Agricultural Experiment Station.

For a technical report on the experimental data see Journal of Agricultural Research, Vol. V, No. 23, March 6, 1916.

The purpose of this bulletin is to give practical directions for the construction and use of the smaller sizes of weirs, such as are suited to the measurement of water on irrigated farms.

said to be "sharp crested." The weir notch must have a definite shape and size. The horizontal distance from the end of the weir crest to the side of the weir box is called "end contraction," and the vertical distance from the crest to the floor of the weir box is called "bottom contraction." When these contraction distances are great enough to cause a pondlike condition, which permits the water to approach the weir notch without any appreciable velocity, the weir is said to have "complete contractions."

The weirs described in this bulletin are the rectangular, Cipolletti, and 90° triangular-notch types, with free fall, sharp crests, and complete contractions. The discharge formulas for these weirs are not confined to the limits imposed upon old formulas. They are correct for high as well as low heads, at least within the range given in the tables.[1] However, in order to lessen the cost for materials for constructing the weirs, the dimensions of the weir boxes, as given in Table 1, are less than required for complete constructions, and therefore the discharges over these weirs will be greater than represented by the formula or discharge tables. The excess reaches a maximum of only about 1 per cent for the higher heads, and consequently can be ignored for practical conditions.

To determine the quantity of water flowing at any time, read the gauge, which gives the "head" or depth of water flowing over the weir notch, and turn to the discharge table in this bulletin for the type of weir used. If the head is measured in feet and decimals, find it in the first column, or if measured in feet and inches, find it in the second column, and following along this line to the right, find the number in the column for the length of weir crest used. This number will be the flow in cubic feet per second, which may be changed into miner's inches—or statute inches—by multiplying by the number of miner's inches equal to a cubic foot per second, as given in the table of hydraulic equivalents on the last page of this bulletin.

ADVANTAGES AND DISADVANTAGES OF WEIRS WITH COMPLETE CONTRACTIONS.

The principal advantages and disadvantages of the types of weirs described herein may be stated as follows:

> *Advantages.*—They are (1) accurate; (2) they are simple and may be constructed by the farmer; (3) they permit moss and floating trash to pass through the ditch without great danger of interfering with the measurement of the water; and (4) they are durable and require no adjustment for proper operation, for there are no working parts.

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[1] A full discussion of the experiments upon which these formulas are based is contained in Journal of Agricultural Research, vol. 5, No. 23, Mar. 6, 1916.

Disadvantages.—(1) They require a considerable pondage above the weir; (2) they can not be used where there is only a slight grade to the ditch; (3) they are not adapted to ditches that carry much sand and silt; and (4) practically all undesirable conditions, such as accumulation of sand and silt above the weir, water approaching the weir with velocity, or injury to the weir crest, tend to give a greater flow of water than that indicated in the tables.

WEIR BOX AND WEIR POND.

When properly constructed either of the three types of weirs described herein is reliable and accurate for the measurement of flowing water. They may be placed in any ditch or canal having sufficient fall, but it is necessary that the ditch be made wider and deeper for some distance upstream from the weir notch. This enlargement is for the purpose of making practically a still-water condition before water flows over the weir. The weir box or weir pond, which is immediately upstream from the weir notch, has a uniform length, width, and depth as given in Table 1, and commencing at approximately 50 feet upstream from the weir the ditch must be enlarged gradually from the regular size of the ditch to the full size of the weir box. The length of this tapering enlargement, stated as 50 feet, really needs to be greater or less as the flow in the ditch is large or small as compared to the size of the weir notch, and it will depend also upon the size of the ditch and the velocity of the water in the ditch.

Where the available grade in the ditch is not great enough to give the required depth of pond by raising the banks for a distance of 50 to 100 feet back from the weir, the bottom may be lowered and the banks raised only enough to give a free fall below the weir notch. However, the weir pond, whether a box or an enlargement of the ditch, must not be allowed to fill with silt and sediment or other débris. The water must approach the weir in straight lines without swirling or eddy currents.

A weir box may be built as shown in figure 1, or a bulkhead may be placed in an enlargement in the ditch as shown in figure 2. This latter arrangement will permit cleaning of the pond with teams and scrapers, and is easy and inexpensive to construct, but because of the sloping banks, the water surface must be wider than where a box is built with vertical sides. The bottom of the ditch for a short distance downstream from the weir should be lined with rock to prevent scouring due to the water falling over the weir notch. Where a complete weir box is built of timber or concrete it looks well, occupies the least land area and has greater permanency, but it is more costly and more difficult to clean. A floor or apron, as given in column K in Table 1, constructed of the same material as the weir box, over-

comes the necessity for lining the ditch with rock below the weir. Precautions should be taken to prevent water from washing under the bottom or around the sides of the box. For most soils, if the earth is puddled with water as it is filled around the box, it will be safe; but where it is sandy or likely to wash, a board 12 inches wide should be placed on edge under the bottom and at the sides near the upper end of the box, to serve as a cut-off wall. The height of the weir crest above the bottom of the ditch downstream from the weir notch will depend upon the size and grade of the ditch, but this height must be such that when the greatest quantity of water is flowing over the weir the water level in the ditch downstream will be below the crest. This is to permit the free passage of air between the bulkhead and the sheet of over-pouring water, which is the required condition for free flow.

Table 1 gives the sizes of weirs best adapted to measuring flows of water varying from one-half to 22 cubic feet per second, and the proper dimensions for each size of rectangular, Cipolletti, and 90° triangular notch weirs.

TABLE 1.—*Weir-box dimensions for rectangular, Cipolletti, and 90° triangular-notch weirs.*

[All dimensions in feet. The letters at the heads of the columns in this table refer to figure 1.]

RECTANGULAR AND CIPOLLETTI WEIRS.

Flow (second-feet).	H. Maximum head.	L. Length of weir crest.	A. Length of box above weir notch.	K. Length of box below weir notch.	B. Total width of box.	E.[1] Total depth of box.	C. End of crest to side.	D. Crest to bottom.	F.[2] Hook-gage distance.	G.[3] Hook-gage distance.
½ to 3	1.0	1	6	2	5½	3½	2¼	2	4	2
2 to 5	1.1	1½	7	3	7	4	2¾	2¼	4½	2
4 to 8	1.2	2	8	4	8½	4½	3¼	2¾	5	2½
6 to 14	1.3	3	9	5	12	5	4½	3¼	5½	3
10 to 22	1.5	4	10	6	14	5½	5	3½	6	3

90° TRIANGULAR NOTCH WEIR.

Flow (second-feet).	H.	L.	A.	K.	B.	E.	C.	D.	F.	G.
½ to 2½	1.00	....	6	2	5	3	2½	1½	4	2
2 to 4½	1.25	....	6½	8½	6½	3½	3¼	1½	5	2½

[1] This distance allows for about ½ foot freeboard above highest water level in weir box.
[2] Equals distance from crest upstream to gauge.
[3] Equals distance from end of crest over to gauge.

As previously stated, using the weir boxes specified in Table 1 will give results within 1 per cent of correct. If smaller boxes are used the actual discharges will be larger than those given in the tables.

Tables 2 and 3 show the percentage increase in discharge caused by weir boxes smaller than required for complete contractions, for rectangular and Cipolletti weirs having crest lengths from 1 to 4 feet, and with heads of six-tenths and 1 foot.

If the smaller boxes are used, discharges should be read from the tables and increased by the percentages given in Tables 2 and 3.

TABLE 2.—*Velocity of approach and percentage of error caused by different end and bottom contractions for rectangular weirs.*

B.	A.	Length 1 foot.				Length 1.5 feet.				Length 2 feet.				Length 3 feet.				Length 4 feet.			
Distance of bottom below crest.	Distance of sides from end of crest.	Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.	
		Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.
Feet.	*Feet.*	*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*	
3.0	2.5			0.132	0.77																
3.0	2.0			.157	.81			0.213	0.82			0.269	0.84			0.342	0.83			0.402	0.87
3.0	1.5			.196	.099			.260	1.08			.317	1.14			.399	1.22			.460	1.29
3.0	1.0			.260	1.40			.337	1.63			.398	1.81			.484	2.06			.543	2.22
3.0	.5			.40	2.94			.477	3.22			.540	3.44			.616	3.72			.661	3.88
2.5	2.5			.150	.74																
2.5	2.0			.178	.82			.242	.88			.302	.94			.391	1.04			.460	1.11
2.5	1.5			.224	1.05			.297	1.21			.362	1.34			.461	1.57			.528	1.69
2.5	1.0			.299	1.58			.385	1.89			.457	2.14			.553	2.50			.623	2.76
2.5	.5			.462	3.42			.549	3.73			.625	3.99			.704	4.25			.760	4.48
2.0	2.5	0.94	0.17	.175	.73																
2.0	2.0	.115	.26	.209	.84			.284	.97			.352	1.11			.458	1.30			.539	1.42
2.0	1.5	.148	.39	.261	1.13			.348	1.42			.424	1.67			.538	2.01			.620	2.28
2.0	1.0	.188	.66	.353	1.83			.450	2.28			.535	2.63			.643	3.14			.733	3.52
2.0	.5	.288	2.05	.538	4.01			.646	4.46			.728	4.80			.829	5.17			.895	5.47
1.5	2.5	.119	.17	.208	.74																
1.5	2.0	.141	.30	.252	.94	1.91	0.53	.341	1.18	0.239	0.74	.424	1.41	0.308	1.07	.539	1.71	0.365	1.33	.638	1.98
1.5	1.5	.175	.40	.314	1.31	.234	.73	.413	1.74	.286	1.01	.512	2.12	.363	1.44	.648	2.65	.416	1.74	.750	3.07
1.5	1.0	.234	.76	.424	2.24	.304	1.24	.544	2.87	.361	1.62	.646	3.40	.435	2.12	.790	4.14	.439	2.49	.889	4.08
1.5	.5	.355	2.26	.648	4.80			.784	5.53			.885	6.09	.552	3.41	1.013	6.77			1.091	7.20
1.0	2.5	.154	.19	.260	.32																
1.0	2.0	.209	.36	.314	1.12			.427	1.57			.532	2.00			.694	2.69			.810	3.15
1.0	1.5	.229	.50	.385	1.59	.311	1.09	.528	2.37	.377	1.55	.645	2.99	.478	2.25	.820	3.91	.552	2.79	.952	4.60
1.0	1.0	.303	1.01	.525	2.83	.400	1.77	.688	3.86	.476	2.39	.825	4.73	.577	3.22	.999	5.87	.650	3.83	1.135	6.77
1.0	.5	.469	2.84	.822	6.00	.573	3.74	.994	7.29	.646	4.38	1.129	8.29	.735	5.15	1.298	9.55	.794	5.64	1.405	10.27
.5	2.5	.221	.25	.350	1.11																
.5	2.0	.265	.50	.417	1.45	.368	1.30	.575	2.40	.460	2.05	.720	3.27	.624	3.34	.943	4.62	.711	4.05	1.120	5.65
.5	1.5	.337	.94	.530	2.20	.453	1.94	.710	3.53	.555	2.84	.875	4.73	.705	4.17	1.119	6.50	.818	5.15	1.308	7.88
.5	1.0	.450	1.84	.716	3.83	.538	3.22	.930	5.65	.704	4.35	1.118	7.23	.862	5.92	1.380	9.40	.975	7.01	1.576	11.2
.5	.5	.695	4.63	1.120	8.25	.852	6.43	1.37	11.0	.970	7.79	1.58	13.3	1.112	9.40	1.83	16.01	1.208	10.50	2.01	18.0

TABLE 3.—*Velocity of approach and percentage of error caused by different end and bottom contractions for Cipolletti weirs.*

B.	A.	Length 1 foot.				Length 1.5 feet.				Length 2 feet.				Length 3 feet.				Length 4 feet.			
		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.		Head 0.6 foot.		Head 1 foot.	
Distance of bottom below crest.	Distance of sides from end of crest.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.	Velocity of approach.	Per cent of error.
Feet.	*Feet.*	*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*		*Ft. per sec.*	
2.0	2.0	......	......	0.260	1.19	......	......	0.322	1.22	......	......	0.386	1.24	......	......	0.488	1.28	......	......	0.561	1.30
2.0	1.5	......	......	.314	1.52	......	......	.397	1.70	......	......	.467	1.84	......	......	.575	2.08	......	......	.648	2.22
2.0	1.0	......	......	.422	2.40	......	......	.514	2.80	......	......	.590	3.15	......	......	.698	3.62	......	......	.769	3.92
2.0	.5	......	......	.655	6.16	......	......	.746	6.41	......	......	.813	6.61	......	......	.896	6.88	......	......	.951	7.01
1.5	2.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1.5	2.0	0.158	0.84	.300	1.34	0.207	1.02	.388	1.49	0.251	1.21	.465	1.61	0.321	1.45	.590	1.82	0.373	1.61	.680	1.98
1.5	1.5	.196	1.11	.378	1.78	.255	1.38	.477	2.10	.304	1.60	.562	2.40	.377	1.95	.693	2.85	.429	2.19	.785	3.17
1.5	1.0	.260	1.70	.508	2.89	.320	2.08	.622	3.53	.331	2.36	.714	4.06	.454	2.77	.844	4.79	.504	3.02	.937	5.31
1.5	.5	.400	3.32	.795	7.29	.469	3.53	.906	7.79	.518	4.20	.989	8.18	.580	4.66	1.094	8.64	.617	4.93	1.163	8.85
1.0	2.5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1.0	2.0	.205	.09	.374	1.60	.274	1.25	.489	2.06	.331	1.55	.586	2.44	.425	2.05	.758	3.13	.492	2.39	.864	3.55
1.0	1.5	.257	1.20	.471	2.20	.335	1.71	.601	2.92	.400	1.55	.710	3.55	.500	2.82	.888	4.53	.569	3.30	1.003	5.19
1.0	1.0	.344	1.84	.643	3.76	.434	2.60	.787	4.83	.501	3.17	.908	5.73	.607	4.06	1.083	7.07	.671	4.60	1.200	7.92
1.0	.5	.529	4.00	1.010	9.20	.622	4.92	1.159	10.28	.690	5.61	1.271	11.08	.770	6.41	1.410	12.09	.826	6.98	1.503	12.72
.5	2.5	......	......	.64	3.3	......	......	.818	4.8	......	......	.968	6.07	......	......	1.21	8.07	......	......	1.391	9.56
.5	2.0	.300	1.11	.508	2.30	.399	1.81	.660	3.64	.487	2.42	.799	4.87	.625	3.40	1.013	6.73	.725	4.09	1.202	8.39
.5	1.5	.377	1.51	.640	3.30	.492	2.55	.818	4.80	.589	3.44	.969	6.09	.737	4.79	1.210	8.08	.847	5.80	1.391	9.56
.5	1.0	.505	2.39	.864	5.40	.636	3.93	1,077	7.58	.750	5.30	1.258	9.43	.908	7.18	1.505	11.95	1.013	8.39	1.688	1.38
.5	.5	.782	6.03	1.390	11.89	.932	8.02	1.605	14.63	1.037	9.43	1.782	16.85	1.173	11.28	2.015	19.80	1.263	12.48	......	......

WEIR CRESTS AND SIDES.

Weir crests and sides should be true, straight, and rigid. The crest must be level, the sides must be set to the proper angle with the crest, and carefully spaced to give the correct length of crest, as indicated by "L" in figure 1 and Table 1. The 90° triangular notch has no length of crest because the sides meet at a point.

It is not necessary that the sides and crest be sharpened to a knife edge, but the edge of the crest on the upstream side must be sharp in the sense that it is not rounded. If a depth of water not less than 3 inches is to be run over the weir, the crest thickness on the edge may be as great as one-fourth inch without the water adhering to the crest, provided the inner edge is sharp. However, if the crest is beveled, this bevel must be placed on the downstream side, for the upstream face of the crest and of the bulkhead which holds the crest must be even and in a vertical position. The downstream face of the opening in the bulkhead must be beveled outward and downward about 45 degrees to insure free passage of air under the sheet of water as it flows over the weir.

Instead of cutting the notch in the bulkhead to just the size desired and leaving this rather rough edge to serve as the crest and sides of the weir notch, it is better to make the opening in the bulkhead at least 1 inch deeper and 2 inches wider than the desired size of weir opening. This will permit attachment of crest and side strips to the bulkhead so as to project about an inch all around, making more perfect edges, and the overpouring sheet of water will not touch the bulkhead.

Wood may be used for the crest and sides, but as it is apt to warp, wear, and become splintered, metal is preferable. For the smaller sizes of weirs, the proper weir opening may be cut out of a single sheet of metal which may be fastened to the bulkhead. For the larger weirs crests and sides made from separate strips of metal having the edges filed true are more practical. This metal should be fairly heavy, to prevent the strips from bending and getting out of alignment easily. A more durable crest may be made of 1½-inch angle iron cut to the required lengths and set into the bottom and sides of the opening cut in the bulkhead. One face of the angle iron will be flush with the upstream side of the bulkhead and the other face will be fastened securely into the opening in the bulkhead. The edge over which the water will pass therefore will project 1½ inches from the opening in the bulkhead, and should be made true with squared edge.

If strips of wood are used for the crest and sides, they usually are fastened to the upstream face of the bulkhead for convenience, but in this case these strips must not be narrow, as this would give a pro-

jection the thickness of the strip, which will reduce the accuracy of the measurement of the water. With whatever type used, the joints formed by the sides and crest must fit nicely without leaving a crack and without causing an offset.

WEIR GAUGE.

The weir gauge, which is used to measure the depth of water flowing over the weir crest, may be an ordinary "ruler" or a hardwood stick graduated to feet and inches, but it is preferable to have it graduated to feet, tenths and hundredths of a foot. It should be set upstream from the weir notch a distance ("F" in fig. 1 and Table 1) at least four times the maximum depth of water ("H") to be run over the crest, or, if placed on the weir bulkhead, the distance "C," measured out from the end of the weir crest, should be at least two times the depth "H." If a complete weir box has been built, the gauge may be fastened to the bulkhead or the side of the box, as indicated in figure 1. If, instead of a weir box, an enlargement has been made in the ditch above the bulkhead, the gauge may be attached to a solid post set just far enough from the bank to insure that it always will be in the water. If a perma-

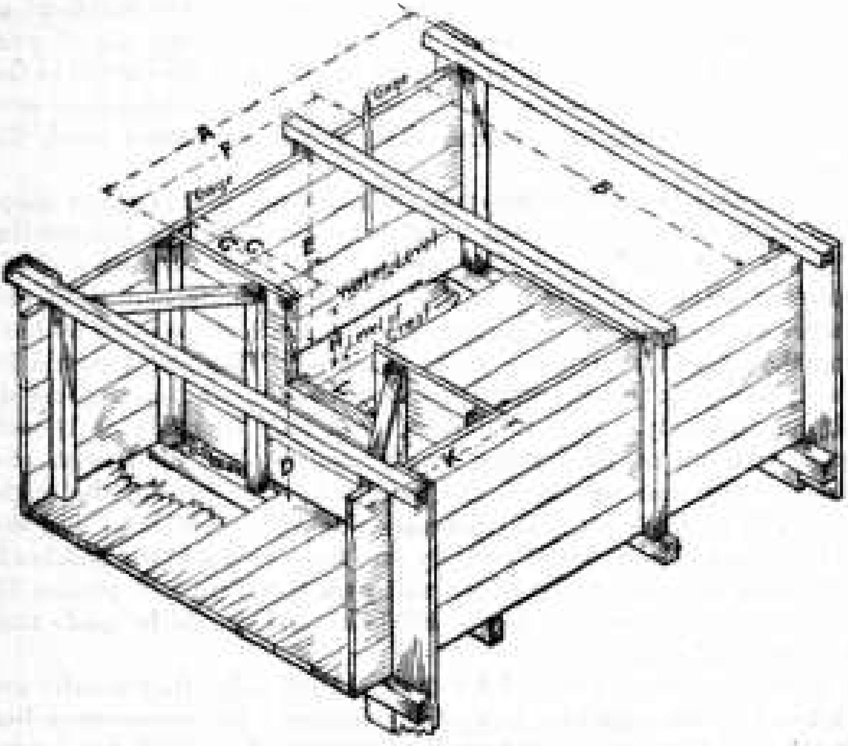

FIG. 1.—Plan of weir box.

nent gauge is not desired, a block or other solid support should be provided at the proper distance upon which to set a scale when taking readings.

The reason for placing the gauge as described is that the depth of water "H," from which the flow over weirs is computed, is measured vertically from the weir crest to the horizontal plane of the still-water surface in the weir pond upstream from the weir. There is a decided curving downward of the water surface near the weir notch, and it is necessary to get beyond the effect of this curvature, called "draw down," in order to get the correct depth of water "H."

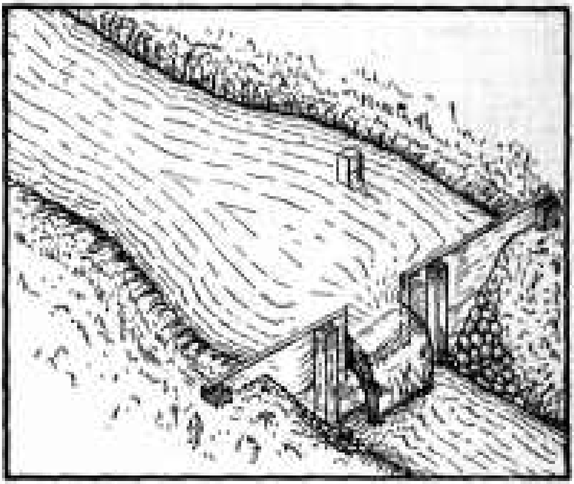

FIG. 2.—Weir notch and bulkhead in weir pond.

The zero of the gauge should be set level with the weir crest for rectangular and Cipolletti weirs, and with the lowest point in the 90° triangular notch, which has no real crest; but this level should not be determined by allowing the water to start to flow over the weir crest and marking the zero of the gauge from that water level, for, in fact, the water level must be appreciably higher than the crest before it will pour over the weir. It would be better to set the gauge with a good carpenter's level. Furthermore, before the beginning of each irrigation system, or oftener, the position of the weir crest and sides and the gauge should be checked carefully, for frost action or settlement in the wet soil may have altered their original position.

Where a hook gauge or an automatic recording gauge is to be used in connection with the weir, a water-tight still-box or gauge well should be provided outside of the weir box and connected to the weir box by means of a pipe laid through the bank below the level of the weir crest. The still-box should be placed upstream from the weir notch, a distance at least as great as shown in column "F" in Table 1, and should be enough deeper than the pipe to prevent silt accumulation from stopping the free passage of water through the pipe. It should be cleaned occasionally. The purpose of the box is to provide a still-water surface at the same level as the water in the weir box.

In order to obtain a correct measurement of the water flowing over a weir it is very necessary that the depth of water "H" be determined accurately. This means that the gauge must be placed accurately and read carefully. To show the error caused by misreading the gauge 0.01 foot, or slightly less than one-eighth inch, Table 4 is given.

Table 4.—*Percentage of error in discharge caused by 0.01 foot error in reading the head.*

Head.		Length of weir crest.					90° notch.
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.	
Feet.	*Feet. Inches.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0.20	0 2⅜	7.2	7.5	7.5	7.6	7.6	....
.30	0 3⅝	5.0	5.1	5.1	5.6	4.8	8.5
.50	0 6	3.5	3.2	3.0	2.9	2.9	5.0
.70	0 8⅜	2.1	1.9	2.1	2.2	2.2	3.9
.90	0 10 13/16	1.8	1.8	1.8	1.7	1.7	2.9
1.10	1 1 3/16	....	1.4	1.3	1.3	1.3	2.2
1.25	1 3	....	....	....	1.1	1.1	2.1
1.50	1 6	....	....	....	0.9	1.0	....

RECTANGULAR WEIRS.

The name is taken from the shape of the weir notch, shown in figure 3. This weir is also known sometimes as the Francis weir. It is one of the earliest forms of weirs used and really is the type from which all other forms have been developed. Because of the simplicity, ease of construction and accuracy with which the crest and sides may be set with the implements ordinarily at hand, this type of weir demands a wider use than it has received in the past few years. It is equally as accurate as the other types. The crest is placed in a horizontal position and the sides extend vertically above the crest. The angle formed therefore is a right angle, which permits the weir to be set easily and accurately by means of a carpenter's square and level. The sides must be placed carefully to give the desired length along the crest. Table 5 gives the discharge over rectangular weirs from 1 to 4 feet in length, computed from the corrected formula.

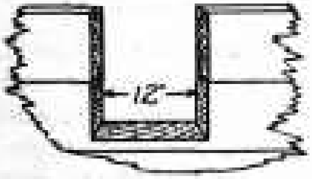

Fig. 3.—Rectangular weir.

TABLE 5.—*Discharge tables for rectangular weirs.*

Computed from the formula $Q=3.247\,lH^{1.48}-\frac{0.566\,l^{1.8}}{1+2\,l^{1.8}}\,H^{1.9}$.

Head in feet.	Head in inches.	Discharge in cubic feet per second for crests of various lengths.				
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.
0.20	2 3/8	0.291	0.439	0.588	0.887	1.19
.21	2 1/2	.312	.472	.632	.954	1.28
.22	2 5/8	.335	.505	.677	1.02	1.37
.23	2 3/4	.358	.539	.723	1.09	1.46
.24	2 7/8	.380	.574	.769	1.16	1.55
.25	3	.404	.609	.817	1.23	1.65
.26	3 1/8	.428	.646	.865	1.31	1.75
.27	3 1/4	.452	.682	.914	1.38	1.85
.28	3 3/8	.477	.720	.965	1.46	1.95
.29	3 1/2	.502	.758	1.02	1.53	2.05
.30	3 5/8	.527	.796	1.07	1.61	2.16
.31	3 3/4	.553	.836	1.12	1.69	2.26
.32	3 13/16	.580	.876	1.18	1.77	2.37
.33	3 15/16	.606	.916	1.23	1.86	2.48
.34	4 1/16	.634	.957	1.28	1.94	2.60
.35	4 3/16	.661	.999	1.34	2.02	2.71
.36	4 5/16	.688	1.04	1.40	2.11	2.82
.37	4 7/16	.717	1.08	1.45	2.20	2.94
.38	4 9/16	.745	1.13	1.51	2.28	3.06
.39	4 11/16	.774	1.17	1.57	2.37	3.18
.40	4 13/16	.804	1.21	1.63	2.46	3.30
.41	4 15/16	.833	1.26	1.69	2.55	3.42
.42	5 1/16	.863	1.30	1.75	2.65	3.54
.43	5 3/16	.893	1.35	1.81	2.74	3.67
.44	5 1/4	.924	1.40	1.88	2.83	3.80
.45	5 3/8	.955	1.44	1.94	2.93	3.93
.46	5 1/2	.986	1.49	2.00	3.03	4.05
.47	5 5/8	1.02	1.54	2.07	3.12	4.18
.48	5 3/4	1.05	1.59	2.13	3.22	4.32
.49	5 7/8	1.08	1.64	2.20	3.32	4.45
.50	6	1.11	1.68	2.26	3.42	4.58
.51	6 1/8	1.15	1.73	2.33	3.52	4.72
.52	6 1/4	1.18	1.78	2.40	3.62	4.86
.53	6 3/8	1.21	1.84	2.46	3.73	4.99
.54	6 1/2	1.25	1.89	2.53	3.83	5.13
.55	6 5/8	1.28	1.94	2.60	3.94	5.27
.56	6 3/4	1.31	1.99	2.67	4.04	5.42
.57	6 13/16	1.35	2.04	2.74	4.15	5.56
.58	6 15/16	1.38	2.09	2.81	4.26	5.70
.59	7 1/16	1.42	2.15	2.88	4.36	5.85
.60	7 3/16	1.45	2.20	2.96	4.47	6.00
.61	7 5/16	1.49	2.25	3.03	4.59	6.14
.62	7 7/16	1.52	2.31	3.10	4.69	6.29
.63	7 9/16	1.56	2.36	3.17	4.81	6.44
.64	7 11/16	1.60	2.42	3.25	4.92	6.59
.65	7 13/16	1.63	2.47	3.32	5.03	6.75
.66	7 15/16	1.67	2.53	3.40	5.15	6.00
.67	8 1/16	1.71	2.59	3.47	5.26	7.05
.68	8 3/16	1.74	2.64	3.56	5.38	7.21
.69	8 1/4	1.78	2.70	3.63	5.49	7.36
.70	8 3/8	1.82	2.76	3.71	5.61	7.52
.71	8 1/2	1.86	2.81	3.78	5.73	7.68
.72	8 5/8	1.90	2.87	3.86	5.85	7.84
.73	8 3/4	1.93	2.93	3.94	5.97	8.00
.74	8 7/8	1.97	2.99	4.02	6.09	8.17
.75	9	2.01	3.05	4.10	6.21	8.33
.76	9 1/8	2.05	3.11	4.18	6.33	8.49
.77	9 1/4	2.09	3.17	4.26	6.45	8.66
.78	9 3/8	2.13	3.23	4.34	6.58	8.82
.79	9 1/2	2.17	3.29	4.42	6.70	8.99
.80	9 5/8	2.21	3.35	4.51	6.83	9.16
.81	9 3/4	2.25	3.41	4.59	6.95	9.33
.82	9 13/16	2.29	3.47	4.67	7.08	9.50
.83	9 15/16	2.33	3.54	4.75	7.21	9.67
.84	10 1/16	2.37	3.60	4.84	7.33	9.84
.85	10 3/16	2.41	3.66	4.92	7.46	10.01
.86	10 5/16	2.45	3.72	5.01	7.59	10.19
.87	10 7/16	2.49	3.79	5.10	7.72	10.36
.88	10 9/16	2.54	3.85	5.18	7.85	10.54
.89	10 11/16	2.58	3.92	5.27	7.99	10.71
.90	10 13/16	2.62	3.98	5.35	8.12	10.89
.91	10 15/16	2.67	4.05	5.44	8.25	11.07
.92	11 1/16	2.71	4.11	5.53	8.39	11.25
.93	11 3/16	2.75	4.18	5.62	8.52	11.43
.94	11 1/4	2.79	4.24	5.71	8.65	11.61
.95	11 3/8	2.84	4.31	5.80	8.79	11.79
.96	11 1/2	2.88	4.37	5.89	8.93	11.98
.97	11 5/8	2.92	4.44	5.98	9.06	12.16
.98	11 3/4	2.97	4.51	6.07	9.20	12.34
.99	11 7/8	3.01	4.57	6.16	9.34	12.53
1.00	12	3.05	4.64	6.25	9.48	12.72
1.01	12 1/8	......	4.71	6.34	9.62	12.91
1.02	12 1/4	......	4.78	6.43	9.76	13.10
1.03	12 3/8	......	4.85	6.52	9.90	13.28
1.04	12 1/2	......	4.92	6.62	10.04	13.47
1.05	12 5/8	......	4.98	6.71	10.18	13.66
1.06	12 3/4	......	5.05	6.80	10.32	13.85
1.07	12 13/16	......	5.12	6.90	10.46	14.04
1.08	12 15/16	......	5.19	6.99	10.61	14.24
1.09	13 1/16	......	5.26	7.09	10.75	14.43
1.10	13 3/16	......	5.34	7.18	10.90	14.64
1.11	13 5/16	......	5.41	7.28	11.04	14.83
1.12	13 7/16	......	5.48	7.38	11.19	15.03
1.13	13 9/16	......	5.55	7.47	11.34	15.22
1.14	13 11/16	......	5.62	7.57	11.48	15.42
1.15	13 13/16	......	5.70	7.66	11.63	15.62
1.16	13 15/16	......	5.77	7.76	11.78	15.82
1.17	14 1/16	......	5.84	7.86	11.93	16.02
1.18	14 3/16	......	5.91	7.96	12.08	16.23
1.19	14 1/4	......	5.99	8.06	12.23	16.43
1.20	14 3/8	......	6.06	8.16	12.38	16.63
1.21	14 1/2	......	6.13	8.26	12.53	16.83
1.22	14 5/8	......	6.20	8.35	12.68	17.03
1.23	14 3/4	......	6.28	8.46	12.83	17.25
1.24	14 7/8	......	6.35	8.56	12.99	17.45
1.25	15	......	6.43	8.66	13.14	17.65
1.26	15 1/8	......	......	......	13.29	17.87
1.27	15 1/4	......	......	......	13.45	18.07
1.28	15 3/8	......	......	......	13.61	18.28
1.29	15 1/2	......	......	......	13.77	18.50
1.30	15 5/8	......	......	......	13.93	18.71
1.31	15 3/4	......	......	......	14.08	18.92
1.32	15 13/16	......	......	......	14.24	19.12
1.33	15 15/16	......	......	......	14.40	19.34
1.34	16 1/16	......	......	......	14.56	19.55
1.35	16 3/16	......	......	......	14.72	19.77
1.36	16 5/16	......	......	......	14.88	19.98
1.37	16 7/16	......	......	......	15.04	20.20
1.38	16 9/16	......	......	......	15.20	20.42
1.39	16 11/16	......	......	......	15.36	20.64
1.40	16 13/16	......	......	......	15.53	20.86
1.41	16 15/16	......	......	......	15.69	21.08
1.42	17 1/16	......	......	......	15.85	21.29
1.43	17 3/16	......	......	......	16.02	21.52
1.44	17 1/4	......	......	......	16.18	21.74
1.45	17 3/8	......	......	......	16.34	21.96
1.46	17 1/2	......	......	......	16.51	22.18
1.47	17 5/8	......	......	......	16.68	22.41
1.48	17 3/4	......	......	......	16.85	22.64
1.49	17 7/8	......	......	......	17.02	22.85
1.50	18	......	......	......	17.17	23.08

CIPOLLETTI WEIRS.

This type of weir is trapezoidal in shape, but the name "Cipolletti" is that of the Italian engineer who proposed its use. As shown in figure 4, the crest of the weir must be level, and the sides placed on a slope of 1 to 4, meaning one unit horizontal to four units vertical. The notch therefore is larger than a rectangle with the same crest length.

It is seen readily that the Cipolletti type of weir, or in fact any weir having sloping sides, is neither so easy to construct nor so easy to check later for accuracy as is the rectangular weir. The great popularity of the Cipolletti weir is due somewhat to its having been proposed at a time when the use of weirs for measuring irrigation water was being considered, but principally because the angle which the sides make with the crest was supposed to make the flow over the weir proportional to the length of the crest. In other words, the flow for a certain head on a 2-foot weir was supposed to be twice the flow over a 1-foot weir for the same depth of water, which would require but a simple weir table for field use. Recent experiments, however, prove that the flow over Cipolletti weirs is not proportional to the length of the crest, which apparently refutes the principal argument in its favor. However, if the sides are placed properly with respect to the crest, and other conditions are observed fully the flow can be measured as accurately over a Cipolletti weir as over a rectangular weir, if the accompanying weir tables, or formula, are used. It is all right, therefore, to use a Cipolletti weir if constructed properly, but where a weir is to be constructed, the rectangular should be chosen in preference to the Cipolletti type. Table 6 gives the discharge over Cipolletti weirs from 1 to 4 feet in length, computed from the corrected formula.

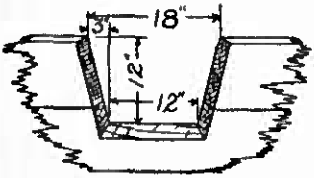

FIG. 4.—Cipolletti or trapezoidal weir.

TABLE 6.—*Discharge tables for Cipolletti weirs.*

Computed from the formula $Q = 3.247\ lH^{1.48} - \frac{0.566\ l^{1.8}}{1+2\ l^{1.8}} H^{1.9} + 0.609\ H^{2.5}$.

Head in feet.	Head in inches.	Discharge in cubic feet per second for crests of various lengths.					Head in feet.	Head in inches.	Discharge in cubic feet per second for crests of various lengths.				
		1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.			1 foot.	1.5 feet.	2 feet.	3 feet.	4 feet.
0.20	2 3/8	0.30	0.45	0.60	0.90	1.20	.86	10 5/16	2.87	4.14	5.13	8.01	10.60
.21	2 1/2	.32	.48	.64	.97	1.29	.87	10 7/16	2.93	4.22	5.52	8.15	10.79
.22	2 5/8	.35	.52	.69	1.04	1.38	.88	10 9/16	2.98	4.29	5.62	8.30	10.98
.23	2 3/4	.37	.55	.74	1.11	1.47	.89	10 11/16	3.04	4.37	5.72	8.44	11.17
.24	2 7/8	.39	.59	.79	1.18	1.57	.90	10 13/16	3.09	4.45	5.82	8.59	11.36
.25	3	.42	.63	.84	1.25	1.67	.91	10 15/16	3.15	4.53	5.92	8.73	11.55
.26	3 1/8	.45	.67	.89	1.33	1.77	.92	11 1/16	3.20	4.60	6.02	8.88	11.74
.27	3 1/4	.47	.70	.94	1.40	1.87	.93	11 3/16	3.26	4.68	6.13	9.03	11.94
.28	3 3/8	.50	.74	.99	1.48	1.97	.94	11 1/4	3.32	4.76	6.23	9.17	12.13
.29	3 1/2	.53	.79	1.04	1.56	2.08	.95	11 3/8	3.37	4.84	6.33	9.32	12.33
.30	3 5/8	.56	.83	1.10	1.64	2.19	.96	11 1/2	3.43	4.92	6.44	9.48	12.53
.31	3 3/4	.59	.87	1.15	1.73	2.30	.97	11 5/8	3.49	5.00	6.55	9.62	12.72
.32	3 13/16	.61	.91	1.21	1.80	2.41	.98	11 3/4	3.55	5.09	6.64	9.78	12.92
.33	3 15/16	.64	.95	1.27	1.89	2.52	.99	11 7/8	3.61	5.17	6.75	9.93	13.12
.34	4 1/16	.67	1.00	1.32	1.98	2.64	1.00	12	3.67	5.25	6.86	10.08	13.32
.35	4 3/16	.70	1.04	1.38	2.07	2.75	1.01	12 1/8	......	5.33	6.96	10.24	13.53
.36	4 5/16	.73	1.09	1.44	2.16	2.87	1.02	12 1/4	......	5.42	7.07	10.40	13.73
.37	4 7/16	.77	1.13	1.50	2.25	2.99	1.03	12 3/8	......	5.50	7.18	10.55	13.94
.38	4 9/16	.80	1.18	1.57	2.34	3.11	1.04	12 1/2	......	5.59	7.29	10.71	14.15
.39	4 11/16	.83	1.23	1.63	2.43	3.24	1.05	12 5/8	......	5.67	7.40	10.87	14.35
.40	4 13/16	.87	1.28	1.69	2.53	3.36	1.06	12 3/4	......	5.76	7.51	11.03	14.56
.41	4 15/16	.90	1.32	1.76	2.62	3.49	1.07	12 13/16	......	5.84	7.62	11.18	14.76
.42	5 1/16	.93	1.37	1.82	2.72	3.61	1.08	12 15/16	......	5.93	7.73	11.35	14.98
.43	5 3/16	.97	1.42	1.89	2.81	3.74	1.09	13 1/16	......	6.02	7.84	11.51	15.19
.44	5 1/4	1.00	1.47	1.95	2.91	3.87	1.10	13 3/16	......	6.11	7.96	11.68	15.41
.45	5 3/8	1.04	1.53	2.02	3.01	4.01	1.11	13 5/16	......	6.20	8.07	11.84	15.62
.46	5 1/2	1.07	1.58	2.09	3.11	4.14	1.12	13 7/16	......	6.29	8.18	12.00	15.84
.47	5 5/8	1.11	1.63	2.16	3.21	4.28	1.13	13 9/16	......	6.37	8.29	12.16	16.04
.48	5 3/4	1.15	1.68	2.23	3.32	4.41	1.14	13 11/16	......	6.46	8.41	12.33	16.26
.49	5 7/8	1.18	1.74	2.30	3.42	4.55	1.15	13 13/16	......	6.56	8.53	12.50	16.48
.50	6	1.22	1.79	2.37	3.53	4.69	1.16	13 15/16	......	6.65	8.65	12.67	16.70
.51	6 1/8	1.26	1.85	2.44	3.64	4.83	1.17	14 1/16	......	6.74	8.76	12.84	16.93
.52	6 1/4	1.30	1.90	2.51	3.74	4.97	1.18	14 3/16	......	6.83	8.88	13.01	17.15
.53	6 3/8	1.34	1.96	2.59	3.85	5.12	1.19	14 1/4	......	6.93	9.10	13.18	17.37
.54	6 1/2	1.38	2.02	2.66	3.96	5.26	1.20	14 3/8	......	7.02	9.12	13.35	17.59
.55	6 5/8	1.42	2.07	2.74	4.07	5.41	1.21	14 1/2	......	7.11	9.24	13.52	17.81
.56	6 3/4	1.46	2.13	2.81	4.18	5.56	1.22	14 5/8	......	7.20	9.36	13.69	18.03
.57	6 13/16	1.50	2.19	2.89	4.30	5.71	1.23	14 3/4	......	7.30	9.48	13.87	18.27
.58	6 15/16	1.54	2.25	2.97	4.41	5.86	1.24	14 7/8	......	7.40	9.60	14.04	18.49
.59	7 1/16	1.58	2.31	3.05	4.53	6.01	1.25	15	......	7.49	9.72	14.21	18.71
.60	7 3/16	1.62	2.37	3.13	4.64	6.17	1.26	15 1/8	......	......	......	14.39	18.95
.61	7 5/16	1.67	2.43	3.20	4.76	6.32	1.27	15 1/4	......	......	......	14.56	19.17
.62	7 7/16	1.71	2.49	3.28	4.88	6.47	1.28	15 3/8	......	......	......	14.71	19.41
.63	7 9/16	1.75	2.55	3.37	5.00	6.63	1.29	15 1/2	......	......	......	14.92	19.65
.64	7 11/16	1.80	2.62	3.45	5.12	6.79	1.30	15 5/8	......	......	......	15.11	19.88
.65	7 13/16	1.84	2.68	3.53	5.24	6.95	1.31	15 3/4	......	......	......	15.29	20.12
.66	7 15/16	1.89	2.75	3.61	5.36	7.11	1.32	15 13/16	......	......	......	15.46	20.34
.67	8 1/16	1.93	2.81	3.70	5.48	7.28	1.33	15 15/16	......	......	......	15.64	20.58
.68	8 3/16	1.98	2.87	3.79	5.61	7.44	1.34	16 1/16	......	......	......	15.82	20.82
.69	8 1/4	2.02	2.91	3.87	5.73	7.61	1.35	16 3/16	......	......	......	16.01	21.06
.70	8 3/8	2.07	3.01	3.95	5.86	7.77	1.36	16 5/16	......	......	......	16.19	21.29
.71	8 1/2	2.12	3.07	4.04	5.99	7.94	1.37	16 7/16	......	......	......	16.37	21.53
.72	8 5/8	2.16	3.14	4.13	6.12	8.11	1.38	16 9/16	......	......	......	16.57	21.78
.73	8 3/4	2.21	3.21	4.22	6.24	8.28	1.39	16 11/16	......	......	......	16.75	22.02
.74	8 7/8	2.26	3.28	4.31	6.38	8.45	1.40	16 13/16	......	......	......	16.94	22.27
.75	9	2.31	3.35	4.40	6.51	8.62	1.41	16 15/16	......	......	......	17.13	22.51
.76	9 1/8	2.36	3.42	4.49	6.64	8.80	1.42	17 1/16	......	......	......	17.31	22.75
.77	9 1/4	2.41	3.49	4.58	6.77	8.97	1.43	17 3/16	......	......	......	17.51	23.01
.78	9 3/8	2.46	3.56	4.67	6.90	9.15	1.44	17 1/4	......	......	......	17.70	23.26
.79	9 1/2	2.51	3.63	4.76	7.04	9.33	1.45	17 3/8	......	......	......	17.89	23.50
.80	9 5/8	2.56	3.70	4.85	7.18	9.51	1.46	17 1/2	......	......	......	18.08	23.75
.81	9 3/4	2.61	3.77	4.95	7.31	9.69	1.47	17 5/8	......	......	......	18.28	24.01
.82	9 13/16	2.66	3.84	5.04	7.45	9.87	1.48	17 3/4	......	......	......	18.47	24.26
.83	9 15/16	2.71	3.92	5.14	7.59	10.05	1.49	17 7/8	......	......	......	18.66	24.50
.84	10 1/16	2.77	3.99	5.23	7.73	10.23	1.50	18	......	......	......	18.85	24.75
.85	10 3/16	2.82	4.07	5.33	7.87	10.42							

90° TRIANGULAR-NOTCH WEIRS.

This type of weir deserves to be more widely used than at present for the measurement of small quantities of water to the irrigator. If the fall is available it may be used for flows as great as 14 second-feet, which would be obtained with a depth of practically 2 feet of water above the vertex, or lowest point, of the angle formed by the sides. However, conditions usually are not favorable for its use for such large heads, and Table 7 gives the discharge for heads up to 1.25 feet. Since the sides meet at a point with no length of crest, a small flow of water that would not pass over one of the other weirs without adhering to the crest and therefore making the measurement worthless, will flow free in the 90° triangular notch and may be measured accurately. The 90° triangular notch is especially applicable from the smallest flow up to 2 or 3 cubic feet per second. Because of the greater depth of water required for this type of weir to discharge a given quantity of water, and the consequent greater loss of grade, one of the other types of weirs usually will be better adapted to large quantities of water.

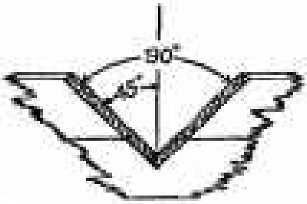

FIG. 5.—Ninety-degree triangular notch weir.

Experiments have shown that the rectangular and Cipolletti weirs with 6-inch crest lengths do not follow the same laws of discharge as the longer weirs, and the discharge formulas given in this bulletin for these weirs do not apply to weirs with a crest length of 6 inches. Therefore, where only a small flow of water is to be measured the use of the 90° triangular notch is especially recommended.

The sides of the 90° triangular notch may be set readily by means of a carpenter's square and level. The notch can be marked out properly by placing the point of the angle between the arms of a carpenter's square at a point which is to be the bottom of the notch and adjusting the square so that the same figures on both arms of the square are at the edge of the board, then if the board is set level the notch will be in the proper position. The sides, therefore, have the same slope.

Table 7 gives the discharge over the 90° triangular notch, computed from the corrected formula.

TABLE 7.—*Discharge table for 90° triangular notch.*

Computed from the formula $Q=2.49\ H^{2.48}$.

Head in feet.	Head in inches.	Discharge in second-feet (Q).	Head in feet.	Head in inches.	Discharge in second-feet (Q).	Head in feet.	Head in inches.	Discharge in second-feet (Q).
0.20	$2\frac{3}{8}$	0.046	0.55	$6\frac{5}{8}$	0.564	0.90	$10\frac{13}{16}$	1.92
.21	$2\frac{1}{2}$	.052	.56	$6\frac{3}{4}$	.590	.91	$10\frac{15}{16}$	1.97
.22	$2\frac{5}{8}$	.058	.57	$6\frac{13}{16}$	.617	.92	$11\frac{1}{16}$	2.02
.23	$2\frac{3}{4}$	.065	.58	$6\frac{15}{16}$	.644	.93	$11\frac{3}{16}$	2.08
.24	$2\frac{7}{8}$	.072	.59	$7\frac{1}{16}$	.672	.94	$11\frac{1}{4}$	2.13
.25	3	.080	.60	$7\frac{3}{16}$	.700	.95	$11\frac{3}{8}$	2.19
.26	$3\frac{1}{8}$	.088	.61	$7\frac{5}{16}$	.730	.96	$11\frac{1}{2}$	2.25
.27	$3\frac{1}{4}$	.096	.62	$7\frac{7}{16}$	.760	.97	$11\frac{5}{8}$	2.31
.28	$3\frac{3}{8}$	.106	.63	$7\frac{9}{16}$	.790	.98	$11\frac{3}{4}$	2.37
.29	$3\frac{1}{2}$	.115	.64	$7\frac{11}{16}$	.822	.99	$11\frac{7}{8}$	2.43
.30	$3\frac{5}{8}$	.125	.65	$7\frac{13}{16}$	.854	1.00	12	2.49
.31	$3\frac{3}{4}$	.136	.66	$7\frac{15}{16}$	.887	1.01	$12\frac{1}{8}$	2.55
.32	$3\frac{13}{16}$	.147	.67	$8\frac{1}{16}$	.921	1.02	$12\frac{1}{4}$	2.61
.33	$3\frac{15}{16}$	.159	.68	$8\frac{3}{16}$	.955	1.03	$12\frac{3}{8}$	2.68
.34	$4\frac{1}{16}$	.171	.69	$8\frac{1}{4}$	.991	1.04	$12\frac{1}{2}$	2.74
.35	$4\frac{3}{16}$	.184	.70	$8\frac{3}{8}$	1.03	1.05	$12\frac{5}{8}$	2.81
.36	$4\frac{5}{16}$	.197	.71	$8\frac{1}{2}$	1.06	1.06	$12\frac{3}{4}$	2.87
.37	$4\frac{7}{16}$	.211	.72	$8\frac{5}{8}$	1.10	1.07	$12\frac{13}{16}$	2.94
.38	$4\frac{9}{16}$	.226	.73	$8\frac{3}{4}$	1.14	1.08	$12\frac{15}{16}$	3.01
.39	$4\frac{11}{16}$	.240	.74	$8\frac{7}{8}$	1.18	1.09	$13\frac{1}{16}$	3.08
.40	$4\frac{13}{16}$	.256	.75	9	1.22	1.10	$13\frac{3}{16}$	3.15
.41	$4\frac{15}{16}$	.272	.76	$9\frac{1}{8}$	1.26	1.11	$13\frac{5}{16}$	3.22
.42	$5\frac{1}{16}$	.289	.77	$9\frac{1}{4}$	1.30	1.12	$13\frac{7}{16}$	3.30
.43	$5\frac{3}{16}$	.306	.78	$9\frac{3}{8}$	1.34	1.13	$13\frac{9}{16}$	3.37
.44	$5\frac{1}{4}$	.324	.79	$9\frac{1}{2}$	1.39	1.14	$13\frac{11}{16}$	3.44
.45	$5\frac{3}{8}$	.343	.80	$9\frac{5}{8}$	1.43	1.15	$13\frac{13}{16}$	3.52
.46	$5\frac{1}{2}$	.362	.81	$9\frac{3}{4}$	1.48	1.16	$13\frac{15}{16}$	3.59
.47	$5\frac{5}{8}$	.382	.82	$9\frac{13}{16}$	1.52	1.17	$14\frac{1}{16}$	3.67
.48	$5\frac{3}{4}$	.403	.83	$9\frac{15}{16}$	1.57	1.18	$14\frac{3}{16}$	3.75
.49	$5\frac{7}{8}$	.424	.84	$10\frac{1}{16}$	1.61	1.19	$14\frac{1}{4}$	3.83
.50	6	.445	.85	$10\frac{3}{16}$	1.66	1.20	$14\frac{3}{8}$	3.91
.51	$6\frac{1}{8}$	.468	.86	$10\frac{5}{16}$	1.71	1.21	$14\frac{1}{2}$	3.99
.52	$6\frac{1}{4}$	.491	.87	$10\frac{7}{16}$	1.76	1.22	$14\frac{5}{8}$	4.07
.53	$6\frac{3}{8}$	.515	.88	$10\frac{9}{16}$	1.81	1.23	$14\frac{3}{4}$	4.16
.54	$6\frac{1}{2}$	.539	.89	$10\frac{11}{16}$	1.86	1.24	$14\frac{7}{8}$	4.24
						1.25	15	4.33

UNITS OF MEASURE.

The *cubic-foot per second*, called second-foot, is a unit of measure for flowing water. When a stream discharges 1 cubic foot of water in one second there is a second-foot flow.

The *acre-foot* is a unit of measure for standing water, and is that volume which will cover 1 acre 1 foot deep. An acre-inch is $\frac{1}{12}$ of an acre-foot, or the volume which will cover 1 acre to a depth of 1 inch.

The *miner's inch* is unsatisfactory and rapidly losing favor as a unit for measuring water, because it is not a definite quantity. It varies with the conditions under which it is used, and therefore is being replaced by the second-foot. In several of the Western States the miner's inch has been defined by law as being a certain fractional part of a second-foot, and these values are given in the accompanying table of hydraulic equivalents.

TABLE OF HYDRAULIC EQUIVALENTS.

1 cubic foot equals 7.48 gallons, or approximately 7½ gallons.

1 cubic foot of water weighs approximately 62½ pounds.

1 cubic foot per second equals 448.83 gallons per minute, or approximately 450 gallons per minute.

1 cubic foot per second flowing for 1 hour equals approximately 1 acre-inch.

1 cubic foot per second flowing for 12 hours equals appromiately 1 acre-foot.

1 cubic-foot per second flowing for 24 hours equals approximately 2 acre-feet.

1 acre-foot equals 43,560 cubic feet, equals 325,851 gallons.

1,000,000 cubic feet equals 22.95 acre-feet.

In California, Nevada, and Montana 1 miner's inch (statutory inch) equals $\frac{1}{40}$ of 1 cubic foot per second.

In Utah, Idaho, and Arizona 1 miner's inch (statutory inch) equals $\frac{1}{50}$ of 1 cubic foot per second.

In Colorado it is generally assumed that 1 miner's inch (statutory inch) equals 1/38.4 of 1 cubic foot per second.

SOME PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO IRRIGATION.

AVAILABLE FOR FREE DISTRIBUTION.

Wood Pipe for Conveying Water for Irrigation (Department Bulletin 155).
Irrigation in Florida (Department Bulletin 462).
Spray Irrigation (Department Bulletin 494).

FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

How to Build Small Irrigation Ditches (Farmers' Bulletin 158). Price, 5 cents.
Use of Alcohol and Gasoline in Farm Engines (Farmers' Bulletin 277). Price, 5 cents.
Practical Information for Beginners in Irrigation (Farmers' Bulletin 263). Price, 5 cents.
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